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A Predictive Business Ranking System: For Local Businesses

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Abstract

To predict the performance of small scale local businesses is a complex problem. Local businesses directly contribute to the overall financial growth of a location or region. The main objective of this research is to develop a model that will provide valuable guidance to entrepreneurs aspiring to enter into the local businesses. Often, small scale businesses is a neglected area due to smaller amounts of turn over associated; but a group of local businesses in a city as a cluster may generate the turnover equivalent to the turnover of a mid-size organization. Machine learning techniques have shown promises in almost all the areas today. In this research, a feed forward neural network is designed to generate forecasts about the financial returns of the local businesses. Not only it predicts the future of the existing businesses, but also provides numerical predictions about the new businesses in the form of profitability ratios for the next financial year.

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Keywords:Feed Forward Neural Network; Local Businesses Prediction, Time Series, Business Forecast, Clustering

1. Introduction

Performance of a local business represents the economic condition of a state or a country. To help a specific region or a town grow financially, it is important to bring success to small scale local businesses. It is crucial to

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avoid all the risks causing failures, when the business is in its initial phase. It is observed that businesses tend to fail due to multiple reasons like lack of knowledge or poor customer satisfaction. Statistically, more than 80% businesses experience the loss or failure in the first stage. Theoretically, there are number of parameters that decide the success or failure for a business. Using these parameters, a system can be developed to forecast the performance of small scale or startup businesses.

Performance of a local business depends upon various characteristics of the place it is set up. For example, the restaurant business is likely to perform better in a tourist destination. It is necessary to understand these location specific parameters, which make any local business successful. There is a very close relation between the location and the type of business suitable for it. Some of the primary factors to determine the suitable business for a location are, dominating age group of customers, weather conditions at the location, dominating culture followed by the buyers, etc. Though, it is not very easy to determine accurately what business will perform best at a particular location.

There are systems like 'Yelp', which generates recommendations for the local customers [1]. These systems are purely based upon the online customer feedback. The recommendations given by such systems help the local customers to select a shop or a service from other alternatives available at the same location. The local customers can see the overall customer rating obtained by a particular restaurant in the neighborhood. Accordingly, they may choose the restaurant to eat or dine for a specific occasion. In such systems, the businesses having maximum star rating consistently is typically preferred by the customers. The scope of such systems is limited to the customers. These systems hardly do any good for the new entrepreneurs. One drawback of such systems is that, business owners can update the fraud ratings to survive in the competition [2]. The competitors attempt to add multiple user ratings online for their own business to increase the count of the 'Average Star Rating' for their business. It is also observed that some of the businessmen who are facing severe competition have given negative ratings for their competitors to divert the customers. Another point is that, there are systems available on stock market prediction to help investment agencies or stock trading individuals [3] but, there is no guidance or help available for the young entrepreneurs who aspire to start a new business and want to bring stability to their venture. There is always a risk or fear of loss in the mind of young entrepreneurs.

Considering the need of the young entrepreneurs and other stake holders in small scale businesses, a system is proposed that not only helps the customers or the investors, but also the young entrepreneurs planning to start a new venture. Especially in the country like India, where young population is high as compared to other age groups, the proposed system can be a guiding tool for young entrepreneurs in setting up a business and in turn boosting the economic conditions of the country. Here, the idea is to design a predictive business ranking system for the different stake holders in small scale local businesses. Fig 1 represents the view point of all the stake holders of small scale local businesses. Each stake holder including the entrepreneurs, existing local business owners or the investment or banking agencies offering business loans will be benefitted by the proposed model.

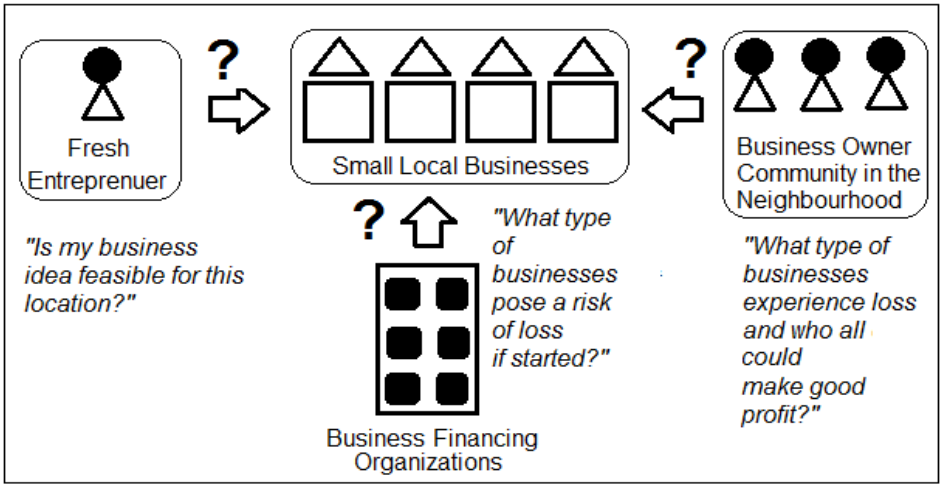

Fig 1: Viewpoint of Stake Holders

Before moving to detail discussion about the proposed business ranking system, the two areas of prior research used in prediction, namely, Time Series Models and Neural Networks are discussed first.

1.1. Time Series Models

Time Series models have been effectively used in prediction and estimations of parameters by providing the historical data [4]. Especially for the financial projections, time series models are widely used. Recent research on Time Series Models for the analysis of New York and Shanghai Stock Market and subsequent implementation of it as effective econometrics tool confirms the high efficiency of the models [5, 6].

As mentioned previously, the performance of a small scale local business is location specific. These location specific businesses have their own dynamics. For example, the performance of a restaurant business is excellent during the holiday season; while education related businesses like stationary shop performs better in the period of examinations. It is not easy to represent the performance of a business in terms of various parameters with a single mathematical equation. India is a highly populated country. This high population has huge impact on the performance of local businesses. In addition to this, in metro cities of India, more than 15 cultures are practiced on an average at a given single suburban location or neighborhood. To capture these dynamic parameters and subsequently carrying out analysis of business data, an effective model is required. Time series can capture such dynamics through the models like ARIMA or VARMAX to make financial forecasts. Considering the potential of time series models in business related predictions [7, 8], it becomes an obvious choice in realization of the proposed system.

1.2. Neural Networks

Neural networks are used effectively to implement the machine learning algorithms. For supervised learning, the neural network has been best option since long time [9, 10]. Business failures are predicted using neural networks [11]. The use of feedback neural networks in stock prediction assures its forecasting capabilities [12, 13]. The way stock prices have effect of variety of parameters; the small scale businesses also observe multiple parameters affecting the performance. To capture the multiple variables associated with the 'Start Up' phase of the small businesses, the neural network based learning becomes the most suitable choice. Any multi-dimensional problem can be effectively modeled using Liebenberg Marquardt neural network algorithm [14]. As seen earlier, the performance of a small scale business depends upon multiple factors. Hence, Liebenberg Marquardt neural network algorithm is useful in prediction of business ranking.

Looking at the various threads useful in the realization of the proposed system, in the next section, let us see in detail the approach used to predict the business ranking. The rest of the paper is organized as follows: section 2 explores the approach for predicting the business ranking. Section 3 discusses the overall framework of the business ranking system. Section 4 presents the evaluation and results obtained during research. Finally, the paper concludes with the observations and some direction for future work.

2. The Proposed Model

One of the obvious parameter that helps any business to grow is the customer satisfaction. In today's world, online feedback is most commonly used method to express the satisfaction level. In the country like India where the number of online users is growing at the rate of more than 80% every year [15], the most appropriate way to capture the feedback is through the website or mobile. The online customer rating and the online mouth publicity have strong impact on specific businesses [16, 17]. In the design of proposed system, the parameters (impact factors) are categories into three types and they are used to predict the business ranking. The three categories are customer centric parameters, financial parameters and business start-up parameters. A separate model is designed for each set of parameters to predict the future of new business. The outcome of these models is given to neural network, which

generates the business recommendation. Now, let us see the approach followed in prediction of business ranking.

2.1. Customer Centric Parameters

At the first stage of the model, customer centric parameters are used to determine, which businesses are successful when weighed against the customer satisfaction. At first, the online data for each local business in the selected area is captured from various sources. There are various third party agent websites or portals offering the online rating facility to small scale businesses. The facility provided by all the small scale businesses to their customers is considered as a parameter to rate the businesses. The area selected for the project is one of the suburban locations called Vile Parle in the city of Mumbai in India. The authenticated data from the agent websites like www.smallbusiness.yahoo.com or www.timecity.com is collected. The customer rating obtained for each business is segregated into two parts 'Positive' and 'Negative'. For example, if an agent web site offers five stars as the maximum rating, then the business receiving star rating from zero stars to two stars falls under the category of 'Negative' rating. Similarly, if the business receives more than two stars, then the feedback falls under the 'Positive' category. Thus, the overall feedback of all the businesses in the location is computed in the form of percentage. Once all the businesses are rated, then the comparative analysis of the businesses is carried out. Using this analysis, it is possible to determine, which business will get the maximum 'Customer Satisfaction Level' among all the other businesses in the locality. Looking at the role of customer centric parameters in deciding business ranking, now, let us see the various financial factors useful in the prediction of business ranking that are covered in the next section.

2.2. Finance Centric Parameters

The second stage of the model focuses on the financial factors and these factors are analyzed using Time Series Models. It is essential for any business owner to weigh the performance of the business in financial figures. There are specific financial parameters used to analyze the performance of any business. Australian Shareholder's Association has listed the top level financial factors for analyzing the performance of businesses [18]. The five factors suitable for local businesses are listed in the Table 1. Alternatively, these factors can be called as profitability ratios. The time series models are used to predict the profitability ratios with the help of historical data. Thus, the model is effective in analyzing the financial performance of all the businesses in the locality.

Table 1: Financial Factors

Ratio	Formula
Positive Ranking Margin	(Total Reviews – Negative Reviews) / (Total Reviews) * 100
Gross Margin	(Gross Profit / Sales) * 100
Net Margin	(Net Profit / Net Sales) * 100
Return of Investment	(Net Income / Total Investment) * 100
Return on Asset	(Net Income / Total Assets) * 100

Looking at customer and finance centric parameters and their role at first and second stage of model in generating useful outcomes, now, these outcomes are given to neural network along with startup parameters to predict the business ranking. Let us see this prediction process called as hybrid approach, which is implemented using neural network in next section.

2.3. Hybrid Approach

In the proposed hybrid approach, the outcomes of both the stages are blended along with the startup parameters to bring out the most accurate model that can address the viewpoints of all stake holders of small scale local businesses. The neural network is used as a machine learning tool to train the network on the behavior of the different local businesses. At first, the businesses are divided in to suitable business categories using the K means clustering algorithm. The algorithm is applied on the complete set of businesses existing at a selected location (Vile

Parle). The value of 'Category Performance against the Customer Feedback' (CPCF) is determined by statistically analyzing the customer feedback for a specific business category. The financial parameters give the value of 'Category Performance against Financial Parameters' (CPFP) for the business category. These two ranks CPFC and CPFP have the range 0 to 10. Rank zero indicating best performance, where as rank 10 indicates worst performance of the category. For example, if a particular business achieved 100% growth in terms of Return on Investment (ROI), then this is the best possible performance. If all the businesses under a particular business category are able to achieve the 100% ROI, then the business category gets the rank zero. The rank of the business category is determined by computing the 'Mode' value of the ROI set given by all the businesses under that category. After computing the two ranks CPFC and CPFP, these ranks are incorporated in the training set along with the start up parameters. Some of the startup parameters worth to mention among the entire set are 'Principle Investment', 'Number of Business Partners' and 'Loan Amount Approved'. After considering all impacting factors from every possible area of local business and categories them into three types as mentioned earlier, now, the neural network is trained using these parameters to predict the business ranking. Looking at the proposed approach, now, let us see the architecture of the system in the next section.

3. Architecture of the System

The first aspect to take into consideration is the design of underlying structure, which represents a model conceived for a kind of prediction system. This section describes in detail the overall framework of the model as shown in Fig 2.

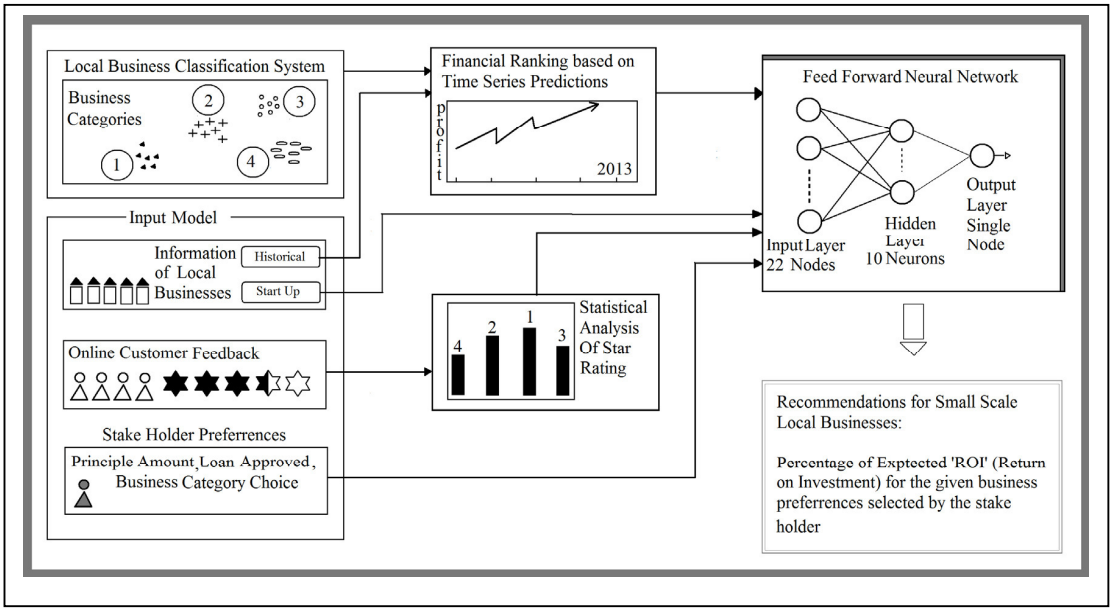

Fig 2. Architecture of Local Business Recommendation System

Figure 2 shows that business categories and local business information is passed as an input to time series model to predict ranking of business in terms of financial aspects. Online customer feedbacks are used to analyze star ratings of the business. Now, the output of these two models along with the start up information is given as an input to train the neural network. The neural network then uses the training set to test and validate the network. The testing is done with the test set comprising of the stake holder preferences. To understand the role of these components in prediction process, each component is discussed in detail in subsequent sections.

3.1. Classification of Local Businesses

To evaluate the overall performance of the local businesses, instead of analyzing it for every business in high population city like Mumbai, it is always better to classify the businesses into various categories. This classification helps in multiple ways. There is a wider view available to the entrepreneur about the local businesses. Rather than just providing the tentative 'Return on Investment' for each local business in the neighborhood, he or she has the choice to select the category of businesses to be evaluated. For example, the entrepreneur can choose any one category out of the four categories given in Table 2 and will get the future of the selected category. As mentioned earlier, the K-Means classification algorithm is used to classify the businesses into the four categories of businesses. Table 2 lists the categories generated for the local businesses in Vile Parle area. The third column in the Table 2, i.e., 'Business Count' represents the percentage of business count with respect to the total businesses in the selected area. Now, this data is given as one of the input to time series models for predicting financial ranking of the businesses.

Table 2: Business Categories for selected location

Business Category	Examples of Businesses	Business Count (%)
Education Related Businesses	Books Shop, Stationary Shop, Photo copy Centre	22
Event Management Businesses	Decorations, Entertainment, Catering Services	21
Service Related Businesses	Private Tuitions, Parlors, Salons, Baby Sitting	18
Direct Shopping Businesses	Selling of Cloths, Electronic Gadgets, Ornaments, Grocery	23

3.2. Input Model

The input model has three different sub-models (blocks). Each block captures a specific set of parameters, which further gets processed to obtain the category ranking. The first block stores the information of the survey conducted on the local businesses. In this case, the area chosen is named as 'Vile Parle'. The primary responsibility of first block in input model is to capture the historical data about the local businesses. All the financial parameters like annual sales, gross profit, net profit, etc. are collected for each financial year. This is the primary data set used to calculate the profitability ratios for the business. Along with the financial information, a set of data that specifies the characteristics of the business is also collected from all the businesses. These business specific characteristics are used to form the clusters of businesses for a given location. For example, in the 'Vile Parle' area the number of businesses serving the student customers is very high. Thus, a cluster can be created with the title 'Education Related Businesses'. The second responsibility of the model is to capture the startup parameters as mentioned in section 2.3 for all the local businesses. The local business information is provided to time series model. The starts up parameters are passed directly to neural network for further processing.

The rating given by customer to small scale business from various websites is captured and passed to the statistical model for further analysis. The preferences such as principle amount, loan approved, business category choice, etc. from stake holder are captured by the input model and passed to neural network for simulation. Looking at various blocks in input model and their role in capturing various parameters useful in prediction of ranking for small scale businesses, now, let us see how these input parameters are processed at various stages of the model.

3.3. Time Series Prediction based on Historical Information

The historical data obtained from the input model is used to generate financial ranking for each business using time series model. As the total number of businesses is high in the selected area, it is necessary to take care of the dynamic behaviors of each local business separately. To analyze the dynamics of all these businesses correctly, multiple models have been tested to select the most appropriate model for each business. For example, 'a mobile shop' is observing the linear growth in gross profit for last ten years. In such case, linear regression model can be

used to predict the business. During the same time period, some other business such as 'Ladies Beauty Parlor' has observed ups and down in terms of profit. In this case, the VARMAX model is chosen among the other models, since; it captures the dynamics of location based businesses. As stated previously, the forecast of financial returns expected from each business is generated using the time series models. The business category rank CPFP (from zero to ten) is obtained after determining the forecast for all the local businesses. Depending upon the performance, prediction is obtained for the businesses and the rank is assigned to the businesses. For example, if ROI prediction for the 'Business 1' is 80% and the value is 30% for 'Business2', then the rank of 'Business 1' is higher than 'Business 2'. The average rank is computed after considering the values for all the five profitability parameters (as given in Table 1). This rank further impacts the rank of respective 'Business Category'. This CPFP rank is used as one of the input predicators to train the neural network. Table 3 shows sample data for business against the financial parameter ROI between the years 2000 and 2012.

Table 3: Sample Data for Time Series Prediction (A-Actual, P-Predicted)

Business	2000 (A)	2002 (A)	2003 (A)	2004 (A)	2005 (A)	2006 (A)	2007 (A)	2008 (A)	2009 (A)	2010 (A)	2011 (A)	2012 (A)	2013 (P)	Rank
B1	27.5	28.9	29.0	31.2	32.3	34.6	34.9	36.1	38.2	38.7	39.3	39.9	40.2	2
B2	35.1	34.0	36.3	35.0	33.4	33.1	31.5	33.8	34.6	34.9	35.4	36.8	36.9	3
B3	47.2	45.6	46.5	44.9	45.4	45.0	47.3	47.8	46.6	46.9	45.9	46.1	46.2	1
B4	38.6	39.1	38.0	37.9	36.4	34.8	31.0	28.4	28.3	24.9	23.7	22.1	20.7	4

3.4. Statistical Analysis of Customer Feedback

The online customer feedback captured in the form of star rating is processed for statistical analysis. Using the star ratings, PFM ('Positive Feedback Margin') ratio for all the businesses is calculated. The formula to compute the PFM is given in the equation 1.

$$PFM = 100 * (\text{Total Feedbacks} - \text{Negative Feedbacks}) / (\text{Total Feedbacks}) \quad (1)$$

After computing the PFM of all the businesses, the value of CRCF is derived by finding the mode value of the set of all the businesses under each business category. This CRCF value is also used as input predicate to train the neural network. In the next section, let us see how neural network generates business recommendations for new entrepreneurs using all input predicators mentioned in previous sections.

3.5. Neural Network Based Recommendation

The final recommendation, i.e., 'how the new business would perform?' is based on the output of the neural network. A three layered neural network has been designed to implement the model. These layers are the Input Layer, Output Layer and the Hidden Layer. The business predicator values (i.e. various parameters, namely, Start Up, CRCF and CRFP) are provided to Input Layer. The output layer produces the value called as 'Expected Return on Investment' for the target business. The neural network carried out data processing in three stages. The three stages are training stage, validation stage and testing stage. Liebenberg Marquardt supervised training algorithm is used to train and validate the neural network. This algorithm has been found useful for similar problems having multiple predicators on the input side. Before selecting this algorithm for the model, the experiments were performed. During experimentation, three supervised training algorithms for the neural network are compared on the basis of various parameters. The three supervised training algorithms compared are, error back propagation algorithm, Gauss-Newton Algorithm and the Liebenberg Marquardt Algorithm. The **Table 4** gives the comparative analysis of the three supervised training algorithms used for neural network based prediction. It can be observed that

the Liebenberg Marquardt based design is much faster than the EBP (Error Back Propagation) algorithm and more stable than Gauss-Newton algorithm. Thus, for complex problems the Gauss Newton method may not converge at all and the error back propagation algorithm becomes inefficient to find the solution to the problem, while the Liebenberg-Marquardt based design leads to the solution.

Table 4: Comparison among different approaches for the problem

Algorithm	Convergence Rate	Average Iteration	Average Time
Error Back Propagation Algorithm	80	172.52	37.5
Gauss-Newton Algorithm	4	5.31	1.4
Lederberg Marquardt Algorithm	100	7.13	1.9

From the comparative analysis, it is evident that the livener Marquardt algorithm is better supervised training algorithm to train the neural network and thus, generating the business ranking and predicting the future of the business. In the training stage, the 'Training Set Data' or 'Sample Data for Training' is provided to the network. Here, the training set represents the data about the existing businesses. This data is the outcome of the prior three sub-models of the system, namely, input model, time series model and the statistical model. The validation samples are automatically chosen from the training set. This particular design is achieved after rounds of testing with different configurations [19]. The supervised learning approach is used to train the network and the output is generated in the form of 'ROI Percentage' value for the given input. Next section covers the result obtained in the research and analysis of it.

4. Evaluation and Results

The performance of the system is evaluated against the 'Root Mean Square Error' (RMSE) value obtained after the simulation of the neural network. The RMSE is one of the most commonly used performance measure parameter to evaluate the performance of the neural network [20]. The performance measured in terms of mean squared error and it is represented on the log scale.

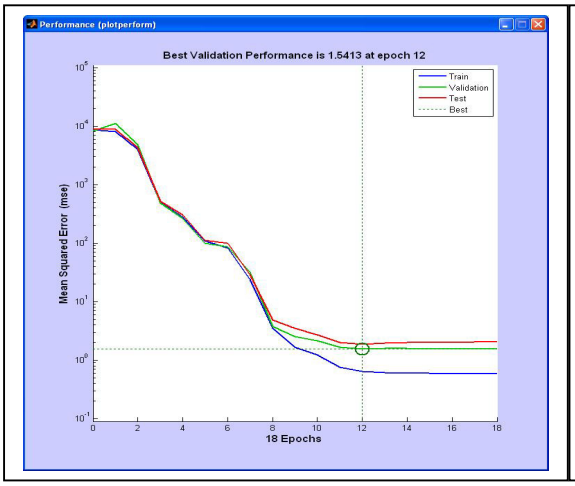

Fig 3. Performance Graph of the Neural Network

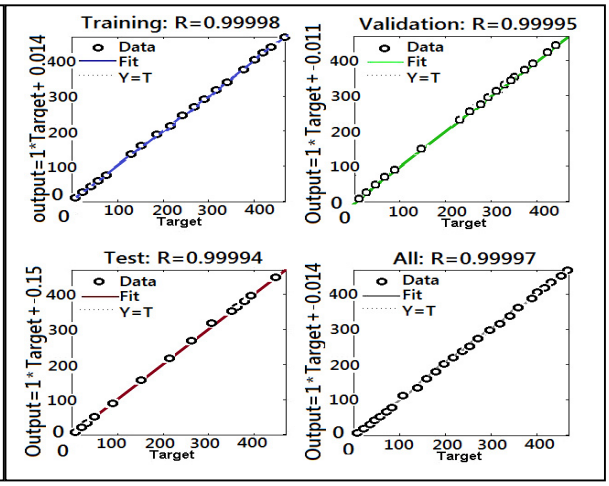

Fig 4. Regression Plots for Training, Validation and Testing

The error value rapidly decreases as the network is trained as shown in Fig 3 . It is clear from the plot that the validation and testing performance is constant after the 12 epochs. This is a fairly reasonable number and the network can be used for real data of upcoming financial years. The time required for the network to perform the training is in seconds. Fig 4 shows the regression plots of the three phases, training, validation and testing respectively of the neural network. This plot compares the output of the neural network against the fitness function used. The regression plot shows the actual network output plotted in terms of the associated target values. As shown in the plot, the output – target relationship closely intersects the bottom left and top right corners. This clearly shows that the training is done optimally. The data is collected from the location Vile Parle (Mumbai) and the time period considered for collection is between financial years 2000 to 2012. The training phase used the training metrics containing the records of the local businesses to train the neural network. The validation of the neural network is performed using the selected samples from the training set. The testing phase evaluates the network on the actual user input. The testing set contains the user preferences. The examples of user preferences (parameters) are, 'Business Category Choice' or the 'Number of Partners in the businesses. These values are selected by the user from the choices given through the user interface. From the overall result of RMSE = 0.9997 obtained by the neural network indicates that the performance of the neural network is highly efficient to resolve the complex problem like local business predictions. To test the claim that the design of neural network with 10 hidden layers with RMSE = 0.9997 is the better design, different neural networks are designed with different combinations of hidden layer settings and the results obtained from these designs are compared. Alterations in the hidden layer settings either results in over fitting or deteriorates the prediction percentage. When the hidden layers are increased to 20 from 10, the performance convergence required higher number of epochs. The performance of neural network was poor, when the hidden layers are reduced to 6 from 10. The figure 5 shows the reduced value of RMSE, when the number of hidden layers are set to 6. Thus, the neural network designed with 10 hidden layers offers 99.97% accuracy for the prediction of the local business performance.

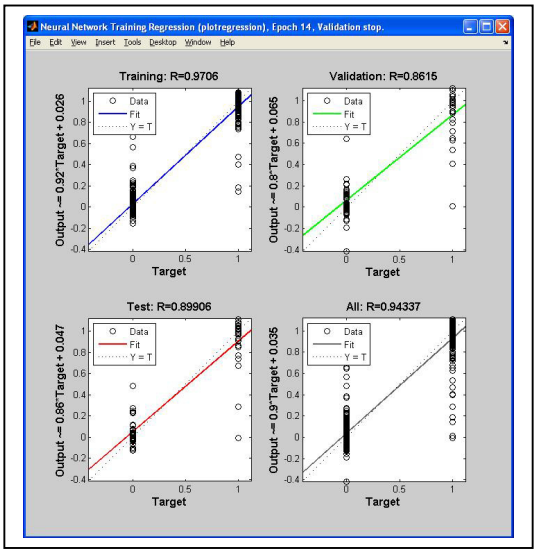

Fig 5. Performance of the Neural Network with 6 hidden layers

5. Conclusion and Future Scope

Considering the state of the problem, the results obtained in this research are encouraging. The objective of serving the small scale business stake holders can be achieved by implementing this model. As far as the efficiency is considered, the model is tested for the highly populated suburban location with total number of small scale businesses greater than 200. Testing of the neural network with larger data set improves the value of RMSE and can

be considered as part of future scope. This clearly indicates that the model can fit well in any city or town with high population of local businesses as well as the customers. The risk of loss or failure can be mitigated with higher probability of success for the new business in the location. From this it can be concluded that the proposed model can be a forward step towards improving the economic condition of a region or a location.

Depending upon the location where the model is being implemented, the variations are possible in the model due to the change in business data of the location. There is a huge scope for the model in terms of integration with the 'Local Business Promotion' drives taken up by the companies like Google and Yahoo. Both of these companies have their portals for local businesses. Local business owners can register their businesses with these portals and can get the benefits of marketing, customer ranking and location specific advertisements. If the proposed model integrated well with these web sites, then it the can provide the advance feature of 'Success Prediction' to these web sites also.

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